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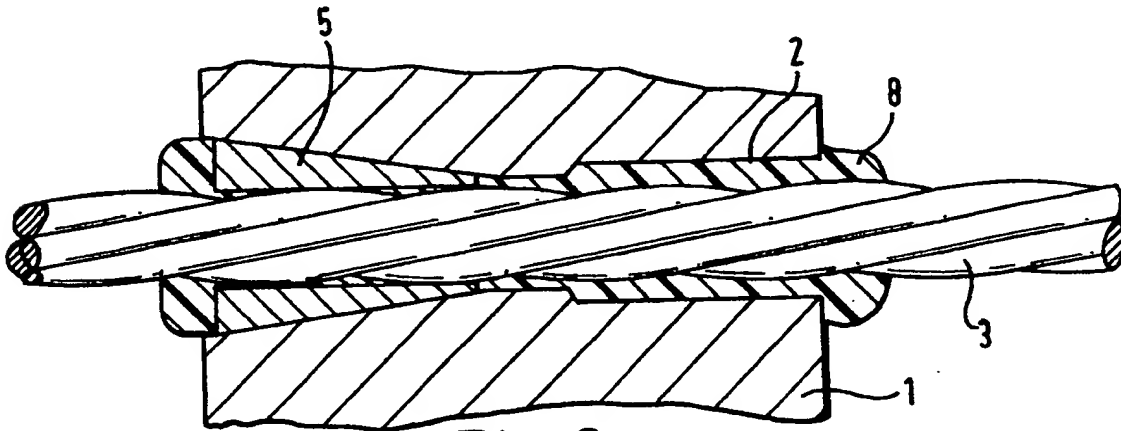
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(54) **Anchorage for stressed reinforcing tendon and method of making the same.**

(57) A stressed strand (3) of a reinforcing tendon is anchored in a bore (2) of an anchoring plate (1) by a combination of a split conical wedge (5) and a body (8) of hardened injected filling material which is substantially confined in extent to the bore and en-

tirely fills the spaces in said bore. The wedge (5) transfers the dead load to the plate (1), while the filling material (8) transfers dynamic load.



*Fig. 2.*

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# ANCHORAGE FOR STRESSED REINFORCING TENDON AND METHOD OF MAKING THE SAME

This invention relates to anchorages for stressed reinforcing tendons for structures, for example, concrete or metal structures having internal or external stressed tendons and other engineering structures having stays constituted by stressed reinforcing tendons. The invention also relates to a reinforced structure including a reinforcing tendon and at least one anchorage therefore.

A reinforcing tendon in a reinforced structure, e.g. a concrete structure, comprises one or more tensioned elements usually of steel and nowadays usually in the form of strand, i.e. a multifilament steel wire. The element or elements are anchored after stressing at each end in an anchorage. At at least one end, there is a "live" anchorage at which a jack has been applied to tension the element or elements and at which the tensioned elements are anchored by means of an anchoring device, for example a split conical wedge lodged in a conical seat in an anchoring body, e.g. a plate. The anchoring plate bears on the reinforced structure directly or indirectly. Adjacent the anchoring plate, the element or elements may be located within a rigid tube or trumpet, and throughout their length in the reinforced structure, or when extending through the air in the case of an external tendon, they are usually encased in a sheath.

Recently there has developed a practice of filling the rigid tube or trumpet adjacent the anchoring body with epoxy resin, which hardens in situ to provide a rigid bond between the element or elements and the tube or trumpet. The epoxy when hardened transfers some of the load of the elements to the structure, thus relieving the anchoring wedges of some of the applied load. This relief is particularly valuable when the load is subject to cyclical variation, e.g. in a bridge. In GB-A-2,095,302, there is described a method in which a curable low viscosity epoxy material is introduced into the trumpet at the anchorage first, and aggregate particles are added later to act as filler. GB-A-2,148,351 describes further processes of filling, including passing the epoxy upwardly through a tube passing through the anchoring plate into the trumpet, where the epoxy fills the space around the stressed elements. It is mentioned that the liquid epoxy may run back through the bores housing the elements and the conical wedges. To prevent escape of epoxy in this manner a rubber sheet is fixed to the outside of the anchoring plate.

US-A-4,619,088 describes injection of epoxy through the bores housing the conical wedges which grip the stressed elements, in order that the grouting material, e.g. epoxy, shall enter a tube closely surrounding the stressed element, in order

to anchor the element to the tube. This tube acts as a secondary member for transferring stress from the stressed element to the anchoring plate. This tube may extend through the plate as far as the outer end of the anchoring plate, in which case the anchoring wedge is located in the tube. Alternatively, the tube has its end close to the narrow end of the conical wedge in the bore in the anchoring plate.

The present invention seeks to provide improved load transfer from the stressed element to the anchoring body, in the case where the stressed element is anchored in the anchoring body by means of a split conical wedge, and using a hardenable fluid material such as epoxy resin.

According to the invention there is provided an anchorage for a stressed reinforcing tendon having an anchoring body and at least one stressed element of said tendon extending through a bore in said anchoring body and anchored in said bore by a split conical wedge in a conical portion of said bore, said bore being substantially entirely filled by hardened filling material providing a direct bond between the stressed element in the bore and the wall of the bore, the extent of said filling material being substantially confined to the bore. Thus the filling material at most projects only slightly from the bore, at least at the inner end of the bore.

In the invention, the stressed element in the bore is directly bonded to the anchoring body by the filling material in the bore, which provides good load transfer between the stressed element and the anchoring body. Thus the filling material bridges the gap between the strand and the wall of the bore. Furthermore, the gaps in the split conical wedge in the bore are entirely filled with the filling material. Preferably the wedge is toothed at its surface which grips the stressed element, and the filling material fills the gaps between the teeth and the stressed element, thereby improving the engagement between the stressed element and the wedge.

Preferably the bore has a length of at least 8 centimetres, more preferably at least 10 centimetres. Preferably at least 50% of the length of the bore is not occupied by the conical wedge.

The invention is particularly applicable to the case where the element is a strand.

The invention also provides a method of making an anchorage as described above, in which the hardenable filling material is injected into the bore from outside the bore at the outside face of the anchoring body and has a viscosity such that it does not flow freely and substantially entirely fills the bore when injected substantially without flowing

out of the other end of the bore, or at least not to more than a small extent. Suitably a thixotropic hardenable material is used. The hardenable material at the time of injection preferably has a "non-sag" thickness (determined according to ASTM D2730) in the range 10 mm to 40 mm at 15°C.

The invention is particularly applicable to an anchoring body having a plurality of bores each housing a stressed element and a conical wedge therefore. In this case preferably the hardenable material is injected into each bore individually.

An embodiment of the invention is illustrated by way of non-limitative example in the accompanying drawing, in which

Fig. 1 is a sectional view of part of an anchorage of the invention during the injection operation,

Fig. 2 is a sectional view corresponding to Fig. 1 showing the filled bore after injection and hardening of the filling material, and

Fig. 3 is a sectional view of completed anchorage.

Fig. 1 shows part of an anchoring plate 1 having a plurality of bores 2, of which only one is shown in the drawing, each bore housing a stressed steel strand 3 which is anchored in a frusto-conical portion 4 of the bore by a split conical wedge 5 of conventional type. Typically the wedge 5 is in three parts, being split along axial planes. It has teeth (not shown) at its inner surfaces which engage the strand 3. Anchoring plates of this general kind, and the split conical wedges, are well-known in this art. Likewise, the application of the present anchorage in a stressed reinforcing tendon in a concrete structure will be apparent to one skilled in the art without further description.

As seen in Fig. 1, the bore 2 of the plate has a length of about 10 cm, of which about 4 cm are occupied by the wedge 5. In the cylindrical portion 6 of the bore, where the stressed portion of the strand 3 extends there is a widening at a shoulder 7 at the region not occupied by the wedge 5.

The vacant spaces of the bore 2 are entirely filled with a hardened filling material 8, such as an epoxy resin. This is injected in liquid state prior to hardening by applying a covering head 9 to the outside face 10 of the anchoring body 1 with a seal 11 to the face 10 around the opening of the bore 2 and an O-ring 12 sealing to the projecting end of the strand 3. There is thus left a hollow space 13 at the mouth of the bore 2, into which hardenable filling material is injected via a passage 14 in the cover 9. Two suitable hardenable materials are mentioned below.

The hardenable material is injected via the passage 14 and has a viscosity such that it flows under the injection pressure but does not flow freely. It therefore fills the space 13 and the whole of the bore 2, including the spaces between the

split portions of the wedge 5 and between the teeth of the wedge 5 and the gripped surface of the strand 3, and also fills all the space around the strand 3 at the portion of the bore not occupied by the wedge 5, finally to emerge at the inner end of the bore to form a small head 15 around the strand. Preferably this head 15 is as small as possible. Suitably it projects not more than 2 cm from the end of the core 5.

After removal of the cover 9 and the seals 11, 12, the filling material is allowed to self-harden (cure) or is hardened for example by heat. There is thus produced the anchored strand 3 shown in Fig. 2 embedded in a rigid body of hardened filling material 8 which completely fills the bore 2 and provides load transfer between the strand 3 and the anchoring body 1, thus relieving the wedge 5 of a part of the load. The material 8 also fills the gaps between the teeth of the wedge 5 and the gripped surface of the strand 3, improving the engagement between the strand and the wedge. As can be seen, only small portions of the material 8 project from the ends of the bore 2.

The presence of the step 7 is to allow the strand 3 to have a deflection where it emerges from the wedge 5 as is often necessary where a plurality of strands are anchored in a single plate.

The effect of the rigid body of filling material 8 is to dampen the force applied by the strand 3 to the wedge 5, so that the wedge absorbs the dead load while the live load (dynamic load) applied to the strand is mainly or entirely transferred directly to the anchoring plate by the filling material 8, so that little or no live load is applied to the wedge. The hardened material 8 in this way improves the fatigue performance of the anchorage. A stay having an anchorage of the present type has been subjected satisfactorily to tests of 2 million loading cycles. The tension of the strand 3 is taken wholly by the plate 1.

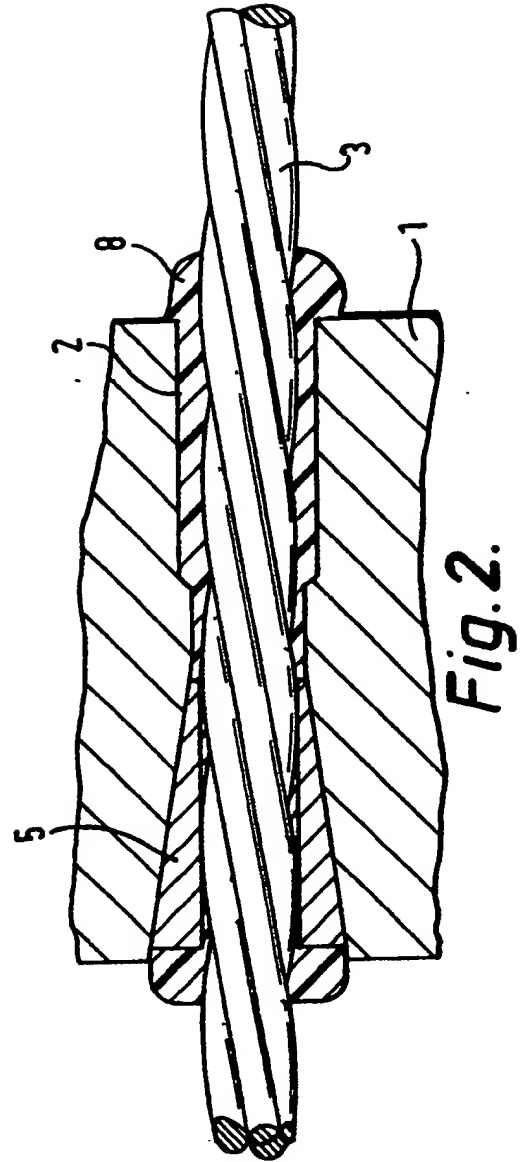
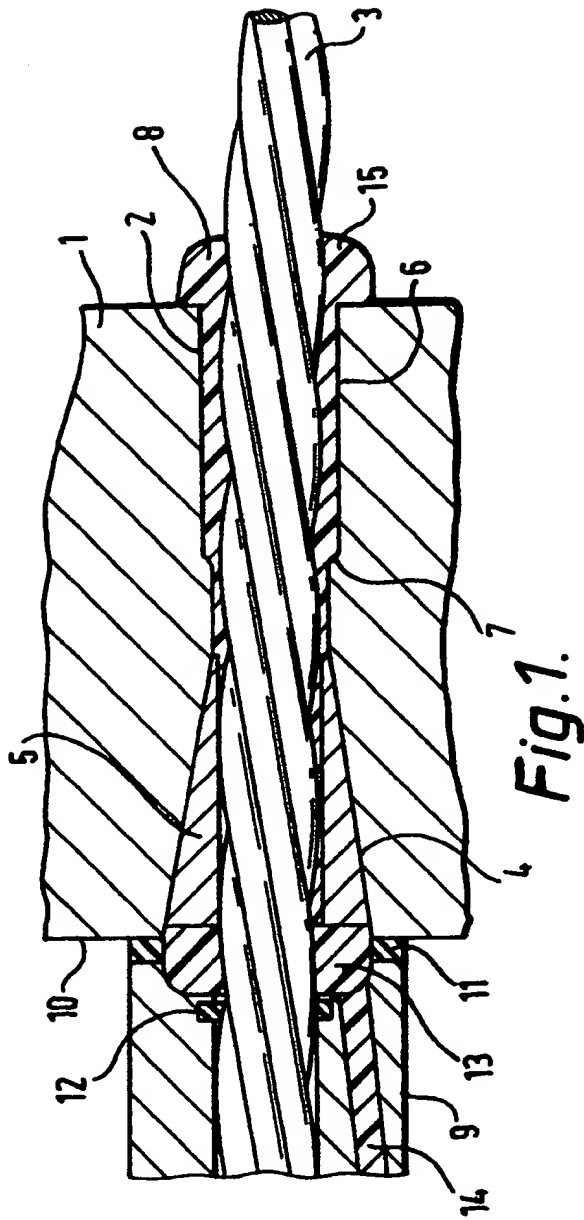
Suitable hardenable materials for injection in the process of the invention are Concrevis (Regd. Trade Name) 1411 and 1428 supplied by Ceilcote GmbH (Biebesheim, Germany). These have non-sag thicknesses at 15°C of 25 mm (1411) and 20 mm (1428).

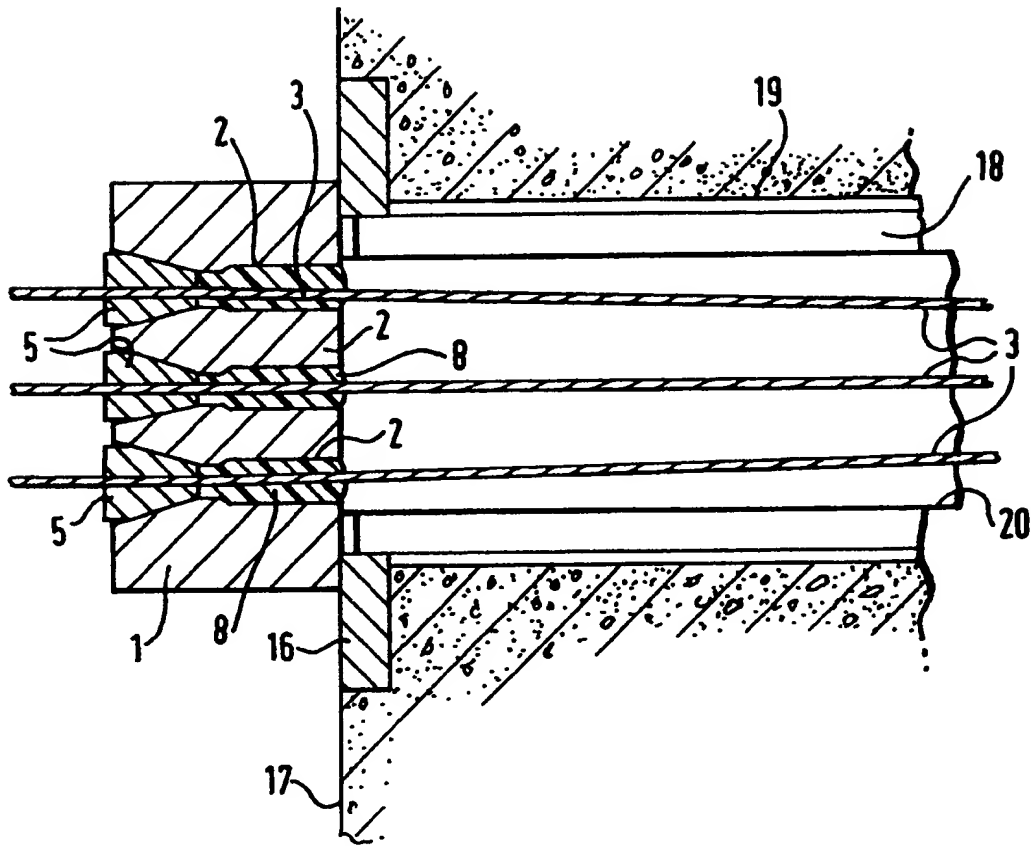
Fig. 3 shows the completed anchorage in section. The anchoring plate 1 bears upon a support ring 16 embedded in a concrete structure 17 which has a passage 18 bounded by a tube 19. The plate 1 is shown with three of the bores 2 each receiving a tensioned strand 3. In practice there are usually a larger number of such bores 2 and strands 3. The strands 3 extend through the passage 18 within a sheath 20, and converge towards each other. As shown in more detail in Figs. 1 and 2, the strands 3 are anchored in the anchoring plate by the combination of the split conical wedges 5 and the

hardened filling material 8.

## Claims

1. An anchorage for a stressed reinforcing tendon having an anchoring body (1) and at least one stressed element (3) of said tendon extending through a bore (2) in said anchoring body and anchored in said bore by a split conical wedge (5) in a conical portion of said bore, said bore being substantially entirely filled by hardened filling material (8) providing a direct bond between the stressed element (3) in the bore and the wall of the bore, the extent of said filling material (8) being substantially confined to the bore. 5 10 15
2. An anchorage according to claim 1 wherein gaps in the split conical wedge (5) in the bore are entirely filled with the filling material.
3. An anchorage according to claim 2 wherein said wedge (5) is toothed at its surface which grips the stressed element, and the filling material fills the gaps between the teeth and the stressed element. 20
4. An anchorage according to any one of claims 1 to 3 wherein said bore (2) has a length of at least 8 centimetres. 25
5. An anchorage according to any one of claims 1 to 4 wherein said split conical wedge (5) occupies less than half the length of said bore (2).
6. An anchorage according to claim 1 wherein said stressed element (3) is a metal strand. 30
7. A method of making an anchorage for a stressed reinforcing tendon comprising the steps of
  - (i) providing an anchoring body (1) having a bore (2) extending through it and at least partly bounded by a frusto-conical surface, 35
  - (ii) locating a portion of an elongate element (3) of said tendon in said bore, stressing said element and anchoring it in the bore by means of a split conical wedge (5) engaging said frusto-conical surface, 40
  - (iii) injecting hardenable filling material (8) into said bore at one end thereof so as entirely to fill the bore, said hardenable filling material having a viscosity such that it does not flow freely, whereby it does not substantially flow out of the other end of said bore, 45
  - (iv) effecting hardening of said hardenable filling material (8) in said bore, said hardenable filling material being selected so that after hardening it is capable of transferring load in said elongate element directly to said anchoring body. 50
8. A method according to claim 7 wherein said hardenable filling material (8) when injected has a no-sag thickness in the range 10 to 40 mm at 15°C. 55





*Fig.3.*



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## EUROPEAN SEARCH REPORT

Application Number

EP 90 31 2047

| DOCUMENTS CONSIDERED TO BE RELEVANT  |   |   |   |
|--|---|---|---|
| Category   | Citation of document with indication, where appropriate, of relevant passages                               | Relevant to claim   | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
| X,Y  | DE-A-3 437 107 (DYCKERHOFF & WIDMANN)<br>* page 11, paragraph 2 - page 12, paragraph 2; figure 7 *<br>- - - | 1,2,3,6,5,<br>7   | E 04<br>C 5/12                                |
| Y  | DE-B-1 234 969 (CABLE COVERS)<br>* column 2, line 49 - column 3, line 8; figure 5 *<br>- - -                | 5   |   |
| Y  | DE-A-3 734 954 (DYCKERHOFF & WIDMANN)<br>* column 8, lines 41 - 60; figure 4 *<br>- - -                     | 5   |   |
| D,Y,A  | US-A-4 619 088 (J. GARCIA-MANCILLA)<br>* column 2, line 40 - column 3, line 24; figure 1 *<br>- - -         | 7,4   |   |
| A  | DE-A-2 911 226 (F. LEONHARDT)<br>* page 5, paragraphs 3 - 4; figure 1 *<br>- - -                            | 1   |   |
| A  | GB-A-1 149 484 (STRESSED CONCRETE DESIGN)<br>- - - - -  | -   |   |
|  |   |   | TECHNICAL FIELDS<br>SEARCHED (Int. Cl.5)      |
|  |   |   | E 04 C  |
| The present search report has been drawn up for all claims   |   |   |   |
| Place of search<br><br>The Hague   |   | Date of completion of search<br><br>17 January 91   | Examiner<br><br>KRIEKOUKIS S.                 |
| CATEGORY OF CITED DOCUMENTS<br>X: particularly relevant if taken alone<br>Y: particularly relevant if combined with another document of the same category<br>A: technological background<br>O: non-written disclosure<br>P: intermediate document<br>T: theory or principle underlying the invention |   | E: earlier patent document, but published on, or after the filing date<br>D: document cited in the application<br>L: document cited for other reasons<br>-----<br>&: member of the same patent family, corresponding document |   |